REFRACTORIES FOR THE GLASS INDUSTRY

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FROM PRODUCT MANUFACTURING TO ENGINEERING SERVICES

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One of the main directions of diversification at BKO JSC is manufacturing products for the glass industry. Aside from the production of the conventional aluminosilicate refractories, BKO JSC develops and produces new types of refractory materials, performs preliminary bench assembly of the structural elements of furnaces (bottom, loading-hopper arch, subchecker arch, feeder troughs). Specialists at BKO JSC provide engineering services for designing individual units of a glassmaking furnace using the BKO's materials. All design solutions are accompanied by recommendations for performing the lining work and putting linings into the working regime.

Key words: refractories for the glass industry, new types of articles, bench assembly, engineering services.

The sharpness of the competition between producers of refractory products objectively requires taking measures to increase the competitiveness of products and services. To meet the continually increasing user requirements BKO is performing work on improving the manufacturing technology for products which are currently being produced and developing new types of refractory products in order to improve their physical and chemical properties and, in consequence, their stability [1]. Product diversification makes it possible, aside from expanding the assortment of products and services, to increase production efficiency, obtain an economic benefit, and provide to the company a stable financial-economic state [2]. As part of the diversification program BKO has determined as a priority the development and manufacturing of products for the glass industry [3]. For building and repairing glassmaking furnaces BKO is developing and producing, aside from conventional products, new types of products and it is designing individual elements of furnaces using BKO's refractory and heat-insulating materials.

CONVENTIONAL REFRACTORY MATERIALS

Fireclay refractories, which are used to build various elements of glassmaking furnaces, are in great demand as always. Their advantage is a relatively low price, but the low physical-chemical indicators limit their use. It should be noted that when making repairs and especially for new construction the ShA and ShB refractories are being increasingly replaced with fireclay refractories which have higher technical characteristics — ShN-38 refractories, and in a number of cases even dense domain refractories ShPD-39 for the masonry of the bottom structure of the regenerator. BKO offers a wide choice of ***high-alumina refractories*** — mullite-silica, mullite, and mullite-corundum with aluminum oxide content from 42 to 90% — of the standard types and with the standard dimensions as well as manufactured according the customer's drawings. MLS-62, MKS-72, and MKV-72 refractories are widely used for building the bottom structure and walls of the regenerator and in a number of cases for its checkerworks also.

BKO maintain high product quality by taking measures developed by its own specialists: a quality management system meeting GOST R ISO 9001–2001 standards has been adopted, internal quality standards with indicators which are tougher than GOST and TU indicators have been adopted, and products are no longer repeatedly exhibited. If necessary, more stringent requirements are secured by contract for delivery of a refractory product [4].

ARTICLES FOR THE CHECKERWORKS OF REGENERATORS

One avenue for improving the construction of a furnace is to increase its efficiency — the use of molded checkerwork elements, made of modern refractory materials, of re-

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TABLE 1. Formats of Molded Refractory Checkerworks Articles (Cup-Shaped Checkerworks)

Format No.	Channel width, mm	Wall thickness, mm	Height, mm
14/12	140	40	120
14/15	140	40	150
15/15	150	40	150
15/12	150	40	120
17/12	170	40	120
17/15	170	40	150

generators. Electromelted baddeleyite-corundum, periclase, and periclase-zirconium refractories with a cross or pot (cup) shape are most often used in foreign countries. They make it possible to obtain high heat emission and smooth operation of the regenerator for the entire furnace run. Fireclay or mullite refractories are used for the colder zones of a regenerator.

In 2004, together with technical specialists from "Ogneupory i tekhnologii" ("Refractories and technologies") drawings were developed for the molded checkerworks refractories for regenerators used in glassmaking furnaces. BKO quickly perfected the production of molded refractories for regenerators for glassmaking furnaces. In 2005 a comprehensive delivery of refractory product from "Klin-steklotara" JSC was made for a new furnace being built in the town of Zaprudnya in Taldom Rayon of Moscow Oblast'. For the first time it was proposed in this design that cup-type molded refractory articles made by domestic producers be used for the checkerworks of a regenerator. The new glassmaking furnace is now up and running. The use of molded checkerwork refractories for a regenerator (Fig. 1) has made it possible not only to solve the problem posed but also to simplify the assembly of the checkerworks, improve the operational characteristics of the furnace (since the checkerworks essentially do not become obstructed, and they can be burned through), and decrease gas consumption by 15% [5].

The following articles are produced: fireclay SHV-37, ShV-42, mullite-corundum MKV-72, periclase-spinel PShAM-1 and PShAM-2 on sintered and fused periclase, respectively, and periclase-zirconium PTs-1 with different sizes and types (Table 1) [6].

ARTICLES MADE OF LOW-CEMENT CONCRETES

One legitimate avenue for technical progress in building industrial furnaces is the use of refractory concretes, which make it possible to simplify substantially and mechanize the process of laying them as well as to simplify substantially and reduce the cost of the manufacture of refractories with a complicated configuration without using pressing equipment.

To obtain an unlimited storage life and prevent damage to articles made of thixotropic concrete, during heating BKO

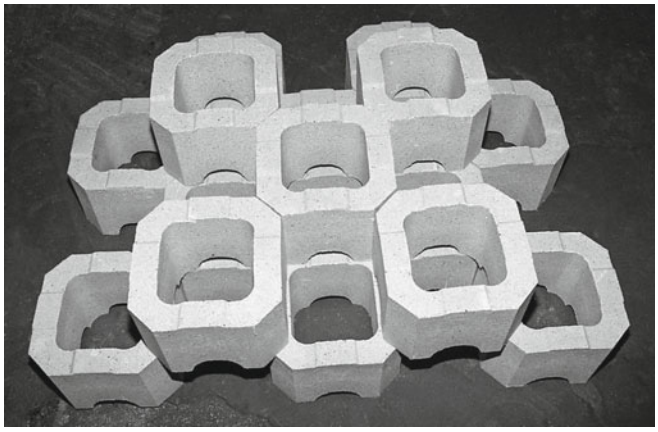

Fig. 1. Molded checkerworks articles for the regenerator of a glassmaking furnace.

precalcinates them at temperature above 1300 °C. Compared with conventional fireclays, high-alumina, and other refractories used previously in separate units of glassmaking furnaces, for articles made of thixotropic concretes there is no limit on the physical-chemical indicators, shape, dimensions, and mass of the articles; in addition, there is not density variation over height.

Together with the Scientific – Industrial Enterprise "Tsentr-Steklo-Gaz" JSC, based on a research center, BKO has performed studies of the glass stability of samples of different types, including samples made of thixotropic concretes. The results of these studies are being actively used in the work. Sections of the feeder channels, cover plates, plate dampers, and other elements of the extraction channels are fabricated at BKO and shipped to customers at the following plants: Dmitrov, Ul'yanovsk, Ékran (Novosibirsk), Svet JSC (Mozhga), Kvarts (Uzbekistan), and others. The brands of refractory concretes which are most resistant to the molten glass were developed on the basis of the results of these studies. These are the materials that can be recommended now for making the elements of glassmaking furnaces.

The burner blocks KShBT have proven themselves well. They are made using fused alumomagnesia spinel, which increases the thermal resistance of the concretes considerably. KShBT burner blocks have been delivered to Chagodoshcha, Tver, and Kamyshin glass container works, Svet JSC (Mozhga), Saratovstroisteklo, and other enterprises in the industry.

BLOCK ARTICLES FOR GLASSMAKING FURNACES (BOTTOM BLOCK)

In 2006 BKO perfected the production of ShSU-33 blocks and in 2008 the production of ShSU-36, ShSU-40, MLS-62, and MKS-72 blocks, used in glassmaking furnaces (bottom block), fabricated by the method of semi-dry pressing in a K-5000 Fritz-Mueller hydraulic press (Germany) with pressing force 5×10^6 kgf (Fig. 2), followed by sintering of the compacts in a tunnel furnace [7]. The produc-

Fig. 2. Fritz-Mueller K-5000 press (Germany) with 5×10^6 kgf pressing force for pressing bottom blocks.

tion of ground blocks with minimal dimensional deviation has been organized for the first time in Russia. The grinding is done using a grinding machine manufactured by the Wassmer Company (Austria) (Fig. 3). Quality control guarantees that the customer will obtain articles with physical-chemical properties, limiting dimensional deviations, and external appearance and internal structure indicators which all considerably exceed GOST 7151–74 requirements (Table 2). The positive reactions of customers confirm the correctness of the technical solutions chosen in the implementation of the BKO project to perfect the manufacture of such articles.

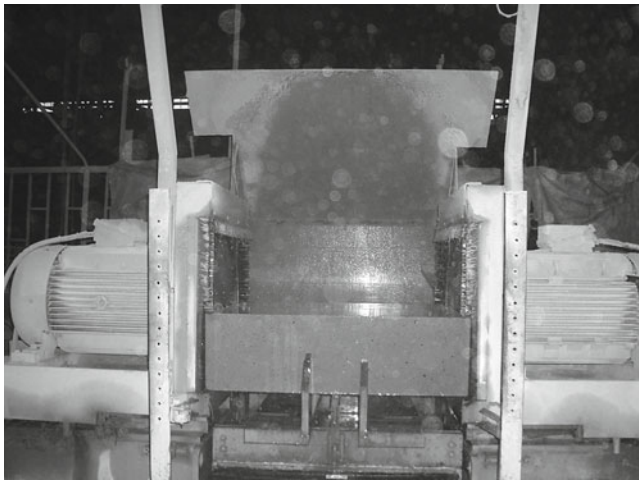

Fig. 3. Grinding ShSU-33 fireclay block No. 1 on the Wasser grinding machine.

BENCH ASSEMBLY FOR THE BOTTOM AND OTHER ELEMENTS OF GLASSMAKING FURNACES

A preliminary bench assembly for individual elements and the entire glassmaking furnace as a whole at the manu-

TABLE 2. Technical Characteristics of Blocks Produced by BKO for Glassmaking Furnaces

Indicator	GOST 7151, GOST 24704 norms for brands				Actual values for brands			
	ShSU-33	ShSU-36	ShSU-40	MLS-62	ShSU-33	ShSU-36	ShSU-40	MLS-62
Limiting dimensional deviations, mm:					Unground article		Ground article	
length		± 6			– 1; + 4		– 1; + 0	
width		± 4			– 1; + 4		– 1; + 0	
thickness		± 4			– 0; + 4		– 1; + 0	
Al_2O_3 mass fraction, %	≥ 33	≥ 36	≥ 40	≥ 62	39.3 – 40.1	39.3 – 40.1	43.9 – 46.5	69.3 – 69.6
Fe_2O_3 mass fraction, %	≤ 1.8	≤ 1.8	≤ 1.5	≤ 1.5	1.46 – 1.67	1.46 – 1.67	1.40 – 1.50	1.14 – 1.24
Open porosity, %	≤ 18	≤ 17	≤ 18	≤ 24	13.3 – 16.9	13.3 – 16.9	12.9 – 17.4	17.5 – 21.6
Apparent density, g/cm^3	Not normalized	Not normalized	Not normalized	Not normalized	2.25	2.25	2.29 – 2.35	2.36 – 2.49
Compression strength, N/mm^2	≥ 25	≥ 30	≥ 50	≥ 25	33.2 – 51.8	33.2 – 51.8	50.0 – 65.7	30.8 – 59.0
Residual dimensional change, %, at temperature:								
1400°C	≤ 0.4	≤ 0.4	≤ 0.4					
1450°C				≤ 0.4	0.0 – 0.2	0.0 – 0.4		
1500°C							– 0.1 + 0.4	– 0.1 + 0.3
Curvature, mm	≤ 2	≤ 2	≤ 2	≤ 2	0.0 – 1.0	0.0 – 1.0	0.0 – 1.0	0.0 – 1.0
Softening onset temperature, °C	–	–	≥ 1450	≥ 1450	–	–	1500 – 1520	1500 – 1510

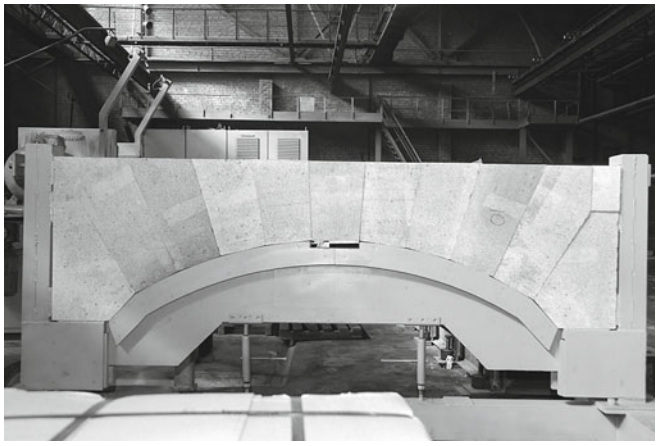

Fig. 4. Bench for assembling a sub-checkerwork arch with the arch assembled on the bench.

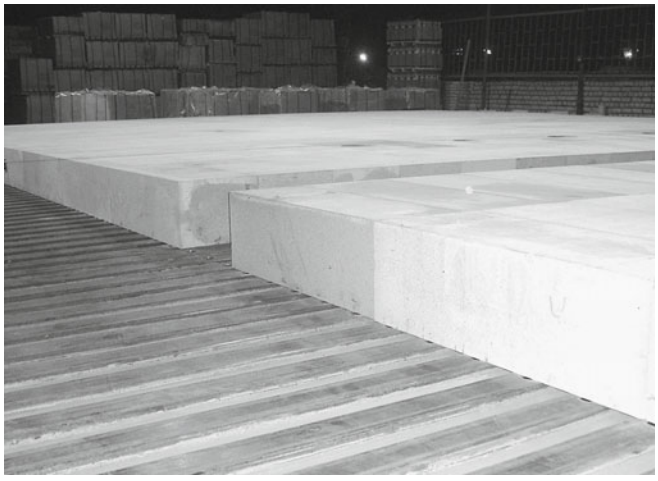

Fig. 5. Assembly bench and furnace bottom for Kamyshin Glass Works.

facturer has now become a common practice of many foreign manufacturers and is one of the mandatory conditions for choosing a supplier of refractory materials. The advantages of pre-assembly on a bench are obvious. This gives the manufacturer the opportunity to see the deficiencies in the fabrication of individual elements of the construction and to fix them before the elements reach the customer. The preparation of the articles and their assembly under factory conditions at the manufacturer is done on specialized equipment using special devices and methods for performing the work, as a result of which assembly quality increases. The customer has the opportunity not only to see the entire structure as a whole and to check the geometric dimensions and technical characteristics but also to decrease considerably the time and resources needed to assemble the structure at his own plant, because pre-assembly permits preparing the conditions for high-quality assembly of other units of the furnace without additional smoothing. When a furnace stands unused and contract work must be paid for it is especially important to decrease the time required for the construction and assembly work.

BKO obtained its first experience in bench assembly of one element of a glassmaking furnace in 2008. At the request of Stal'proekt JSC for the Gomel' glass container works (designed by the German company Horn) the sub-checkerwork arches of regenerators were built using MLS-62 mullite blocks; one requirement of the customer was preliminary bench assembly. A compact dismantable bench, on which the blocks were assembled, was built for this purpose (Fig. 4). The customer's representatives received the assembled arches at the manufacturing plant. In the review by Stal'proekt JSC it is stated: "During repeated checks at the manufacturing plant we verified the high quality of work performed to fulfill the order: the physical-chemical indicators meet the requirements of the standards, the geometric dimensions meet completely the requirements of the designers, length deviations of 2500 mm long arch structures assembled on the bench did not exceed 3 – 5 mm and the height deviations did not exceed 1 mm. All elements were cut from large-block mullite articles, the accuracy of the geometric dimensions was attained by grinding each article separately, each article of the arches was numbered, and the packaging protected the products."

Subsequently, sub-checkerwork arches with a similar construction were pre-assembled on a bench for Dmitrovsteklo JSC, loading-hopper arches made of ShSU-33 fireclay blocks were made for "Ruzaevskii stekol'nyi zavod" JSC, and flat arches were made for regenerators for Salavatsteklo JSC.

In December 2009 – February 2010 work on designing and building a bench, developing a technology for preparation and assembly of block articles on the bench, and quality monitoring of the blocks was performed for an order to deliver 92 tons of refractories for the bottom of a tank furnace at the Kamyshin Glass Container Works, which is part of the transnational corporation St. Gobain. The bench (Fig. 5) was made with height deviations for individual elements from – 0.2 to + 0.6 mm with norm ± 1.0 mm.

To make sure that the requirements for minimum dimensional deviations of the assembled structure of the bottom are satisfied and that the diagonals of each element of the assembly are equal, after sintering all six faces of each block were ground on a grinder made by the Austrian company Wassmer. Some blocks with nonstandard dimensions (length less than 1000 mm, width less than 400 mm, and thickness less than 300 nm) were obtained by cutting standard 1000 × 400 × 300 mm blocks on a stationary cutting bench with a circular saw. The cut blocks were also ground on all sides. Openings with diameters 200 and 250 mm were drilled in some articles under thermocouples and electrodes, respectively.

Successful assembly of the articles was accomplished only by meeting strict requirements on the tolerances:

– length, width, and height deviations — ± 0.25 mm;

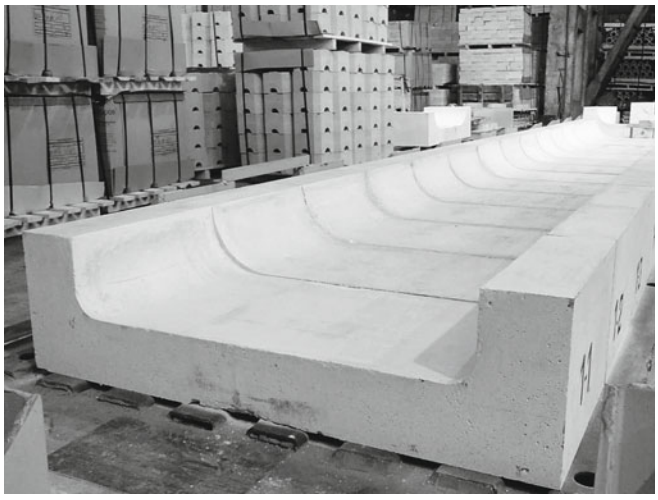

Fig. 6. Bench assembly of the feeder troughs of the glass forming machines.

– slope (deviation from a right angle) on all sides — no more than 0.2 mm.

Representatives of the customer — St. Gobain Company — received the bench assembly on February 5, 2010. The specialists from the Kamyshin Glass Container Works performed all required measurements of the linear dimensions (length, width, diagonal), height deviations, nonplanarity of the side surfaces, gaps between the articles in the assembly of each constituent element of the bottom: melt zone, fining zone, loading hoppers. The results of the measurements showed that all norms were met with a considerable margin.

Immediately after the furnace bottom for Kamyshin Glass Container Works on the new bench was accepted, a preliminary assembly of the feeder troughs of the glass forming machines of the "Krasnoe Ékho" Glass Works was made. BKO has been supplying troughs for feeders in different glass works for six years now. Grinding of trough sections was perfected in past years, and this year a bench assembly of three sets of troughs has been done for the first time (Fig. 6).

ENGINEERING SERVICES

To refresh and expand its product line BKO has been operating its own scientific – research subdivision since December 2001 — Center for Improving Technologies and Products (CITP) [8]. The Center has performed a series of works on the development of refractory materials for different sectors of industry; some of these materials are now being serially produced. Thus, BKO not only produces modern products, demanded by consumers, but it also develops (designs) and adopts them.

The Center's engineering subdivision develops designs for linings of various heating plants and makes recommendations for operating them so as to attain the maximum technical service life. In addition, working together with researchers who are developing new materials with extended service life technical solutions taking account of the particulars of these materials are proposed. The construction developed for individual parts and units of furnaces takes account of the technical and technological possibilities of BKO's operating plant.

In 2008 – 2010 specialists from the engineering division developed a number of designs for glass enterprises:

– bench assembly for the furnace bottom for KSZ JSC (Kamyshin);

– bottom for a glassmaking furnace: arrangement of the blocks of a multilayer bottom (sequential layers) for Interglass JSC (Tokmok, Kyrgyzstan), Steklotekh JSC (Bongadinskii, Tyumen Oblast', Volgograd Oblast'), Veda-Pak JSC (Kingisepp, Leningrad Oblast');

– arrangement of checkerworks for a generator for Fakel JSC (Fakel, Republic of Urmutia);

– dome parts of a float tank for Interglass JSC (Tokmok, Kyrgyzstan);

– arches for the loading hoppers at Rasko JSC (Aponino, Valdimir Oblast', Compagnie de Saint Gobain), Lisichansk Glass Works Proletarii JSC (Lisichansk, Ukraine);

– technical solutions for repairing the arches of the loading hoppers using refractory concrete at Mirandel JSC (Dmitrov, Moscow Oblast'), replacement of the blinds of the loading hopper with concrete articles for Smerdomskii Steklozavod JSC (Smerdomskii, Vologda Oblast').

The engineering services package includes, aside from design, the development of recommendations for using materials; when concrete are used, recommendations are made and consultations are held with the customer concerning preparation, laying and heat-treatment of concrete articles and linings, and putting them into the working regime.

CONCLUSIONS

To become more competitive BKO JSC is developing and expanding the spectrum of products and services that it offers. One of the main directions of development is the production of refractories for the construction and repair of glassmaking furnaces.

The production of cup-shaped checkerworks for regenerators, articles from low-cement concretes, and block articles for the bottom masonry of tank furnaces has been perfected in the last five years.

In product development a bench has been constructed and the technology for bench assembly of the bottom and other elements of glassmaking furnaces has been perfected.

Specialists at the BKO JSC provide engineering services for the design of individual units of a glassmaking furnace using BKO's own materials. All design solutions are accompanied by recommendations on performing lining work and putting the lining in the working regime.

In summary a full spectrum of services involving the production and use of refractory materials for building and repairing glassmaking furnaces has been perfected and is now offered to customers.

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